CLAIMS

Therefore, having thus described the invention, at least the following is claimed:

1. An adsorbent comprising an alkali metal promoted, mixed trivalent layered double hydroxide (LDH) composition, wherein the mixed trivalent layered double hydroxide (LDH) composition is heated to a temperature ranging from about 300°C to 450°C to provide the adsorbent having an adsorption capacity of at least 0.8 millimoles of CO_2 adsorbed per gram of adsorbent.

2. The adsorbent of claim 1, wherein the alkali metal is at least one metal selected from the group consisting of potassium, sodium, and lithium.

3. The adsorbent of claim 1, wherein the alkali metal is potassium.

4. The adsorbent of claim 1, wherein the alkali metal promoted, mixed trivalent metal LDH composition is represented by the formula $[Mg_6Al_{2(1-o)}Ga_{2o}(OH)_{16}CO_3 \cdot 4H_2O] \cdot p(K_2CO_3)$, wherein p is in the range from greater than 0 to about 0.02, and wherein o is in the range from greater than 0 to about 0.3.

5. The adsorbent of claim 1, wherein the alkali metal promoted, mixed trivalent metal LDH composition is represented by the formula $[Mg_6Al_{2(1-q)}La_{2q}(OH)_{16}CO_3 \cdot 4H_2O] \cdot r(K_2CO_3)$, wherein r is in the range from greater than 0 to about 0.02, and wherein q is in the range from greater than 0 to about 0.1.

6. The adsorbent of claim 1, wherein the alkali metal promoted, mixed trivalent metal LDH composition comprises at least one trivalent metal selected from gallium, lanthanum, indium, the lanthanide series of elements, or combinations thereof.

7. The adsorbent of claim 6, wherein the trivalent metal is gallium.

8. The adsorbent of claim 6, wherein the trivalent metal is lanthanum.

9. The adsorbent of claim 1, wherein the adsorbent has a desorption rate, indicated by a first order rate constant, of about 0.05 to 0.24 per minute.

10. The adsorbent of claim 1, wherein the adsorbent has a working capacity of at least 0.05 millimoles per gram CO_2 per gram of adsorbent.

11. An adsorbent comprising an alkali metal promoted, mixed trivalent layered double hydroxide (LDH) composition, wherein the mixed trivalent layered double hydroxide (LDH) composition is heated to a temperature ranging from about 300°C to 450°C to provide the adsorbent, and wherein the alkali metal promoted, mixed trivalent metal LDH composition has the following general formula:

$$[M1_{1-x}(M2_yM3_{(1-y)})_x(OH)_2(A)_{x/2} \cdot z\ H_2O] \cdot v\ [M4_wCO_3]$$

wherein the subscript "x" is a number between 0 an 1; the subscript "y" is a number ranging from greater than 0 to about 0.05; "z" is a number ranging from 0 to about 8; the subscript "w" is the integer 1 or 2, wherein when "w" is the integer 1 the CO_3 becomes HCO_3; "v" is a number ranging from 0 to about 0.01; "M1" is a divalent metal selected from magnesium (Mg), calcium (Ca), strontium (Sr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), and zinc (Zn); "M2" and "M3" are each a trivalent metal selected from aluminum (Al), chromium (Cr), Mn, Fe, Co, lanthanum (La), cerium (Ce), galium (Ga), indium (In), the lanthanide series of metals, and mixtures thereof; "A" is an anion selected from CO_3, SO_4, and HPO_4; and "M4" is an alkali metal selected from sodium (Na), potassium (K), robidium (Rb), cesium (Cs), and lithium (Li).

12. The adsorbent of claim 11, wherein "M1" is Mg.

13. The adsorbent of claim 11, wherein "M2" is selected from Al, Ga, and La.

14. The adsorbent of claim 11, wherein "M3" is a trivalent metal selected from Ga, La, In, and the lanthanide series of metals.

15. The adsorbent of claim 11, wherein at least one of "M2" and "M3" is Al.

16. The adsorbent of claim 11, wherein "M4" is K.

17. The adsorbent of claim 11, wherein the alkali metal promoted, mixed trivalent layered double hydroxide (LDH) composition is represented by the formula: $[Mg_6Al_{2(1-o)}Ga_{2o}(OH)_{16}CO_3 \bullet 4H_2O] \bullet p(K_2CO_3)$, wherein p is in the range from greater than 0 to about 0.02, and wherein o is in the range from greater than 0 to about 0.3.

18. The adsorbent of claim 11, wherein the alkali metal promoted, mixed trivalent layered double hydroxide (LDH) composition is represented by the formula: $[Mg_6Al_{2(1-q)}La_{2q}(OH)_{16}CO_3 \bullet 4H_2O] \bullet r(K_2CO_3)$, wherein r is in the range from greater than 0 to about 0.02, and wherein q is in the range from greater than 0 to about 0.1.

19. The adsorbent of claim 11, wherein the adsorbent has a working capacity of at least about 0.05 millimoles CO_2 per gram of adsorbent.

20. The adsorbent of claim 11, wherein the adsorbent has a working capacity of at least 0.5 millimoles per gram CO_2 per gram of adsorbent.

21. A method of separating carbon dioxide from a gas mixture comprising carbon dioxide and water vapor, the method comprising:

providing at least one adsorption zone comprising an alkali metal promoted, trivalent metal layered double hydroxide (LDH) adsorbent having an adsorption capacity of at least 0.8 millimoles of CO_2 adsorbed per gram of LDH adsorbent;

passing the gas mixture comprising water vapor and carbon dioxide through the at least one adsorption zone wherein the alkali metal promoted, mixed trivalent metal LDH adsorbent adsorbs at least part of the carbon dioxide from the mixture to provide a carbon dioxide-depleted gas; and

regenerating the alkali metal promoted trivalent metal LDH adsorbent to provide a a carbon dioxide-rich gas.

22. The method of claim 21, wherein the passing step is at least one process selected from pressure swing adsorption, temperature swing adsorption, and combinations thereof.

23. The method of claim 21, wherein the adsorption zone comprises at least one member selected from a single adsorption bed, a plurality of adsorption beds, a rotating kiln adsorption unit, and combinations thereof.

24. The method of claim 21, wherein the gas mixture further comprises at least one gas selected from hydrocarbons, carbon monoxide, H_2, O_2, N_2, and combinations thereof.

25. The method of claim 24, wherein the gas mixture comprises at least one hydrocarbon selected from naphtha, methane, ethane, ethene, and combinations thereof.

26. A method of separating carbon dioxide from a gas mixture using an adsorption process comprising:

passing the gas mixture comprising water vapor through at least one adsorption zone comprising an alkali metal promoted, mixed trivalent metal layered double hydroxide (LDH) adsorbent wherein the adsorption zone being at a first temperature and a first pressure, and wherein the alkali metal promoted, mixed trivalent metal LDH adsorbent adsorbs at least part of the carbon dioxide from the gas mixture;

separating a portion of the carbon dioxide from the gas mixture to form a carbon dioxide-depleted gas; and

regenerating the alkali metal promoted, mixed trivalent metal LDH adsorbent, wherein the adsorption zone being at a second temperature and a second pressure.

27. The method of claim 26, wherein the adsorption process is a cyclic adsorption process.

28. The method of claim 26, wherein the cyclic adsorption process is selected from a pressure swing adsorption process, a temperature swing adsorption process, and combinations thereof.

29. The method of claim 26, wherein the first temperature is less than the second temperature.

30. The method of claim 26, wherein the first pressure is greater than the second pressure.

31. A method of separating carbon dioxide from a gas mixture using an adsorption process comprising:

contacting the gas mixture comprising water vapor with alkali metal promoted, mixed trivalent metal layered double hydroxide (LDH) adsorbent having an adsorption capacity of at least 0.8 millimoles of CO_2 adsorbed per gram of LDH adsorbent; and

separating a portion of the carbon dioxide from the gas mixture.

32. The method of claim 31, further comprising:

regenerating the alkali metal promoted, mixed trivalent metal LDH.